McCULLOUGH MOUNTAINS G-E-M RESOURCES AREA

(GRA NO. NV-36)

TECHNICAL REPORT

(WSAs NV 050-0425 and 050-0435)

Contract YA-554-RFP2-1054

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Final Report

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TABLE OF CONTENTS

Table of Contents cont.

Table of Contents cont.

Table of Contents cont.

Page

LIST OF ILLUSTRATIONS

EXECUTIVE SUMMARY

The McCullough Mountains Geology-Energy-Minerals (GEM) Resource Area (GRA) is a few miles east of Jean, which is on Interstate Highway 15, in Clark County, Nevada. There are two Wilderness Study Areas (WSAs), NV 050-0425 and 050-0435.

In the southern half of the GRA most of the rocks exposed are intensely metamorphosed rocks perhaps one billion years old. In the northern half, and in parts of the southern half, are exposed sediments and volcanic rocks mostly 20 million to 30 million years old. The available geological maps of the GRA are very generalized.

Three mining districts are in or adjacent to the GRA. The Alunite district, a few miles northeast of WSA NV 050-0425, has produced less than $100,000 in gold. The Crescent district, adjoining the south edge of WSA NV 050-0435, is credited with about $60,000 in gold, silver and lead. The Sunset district, three miles west of WSA NV 050-0435, has recorded production of a few thousand dollars in gold, silver and lead.

There are numerous patented claims in the Crescent and Alunite districts, but none in the Sunset district; none of the patented claims are within two or three miles of either WSA. There are numerous unpatented claims in the Crescent district, and some of them lie adjacent to or within WSA NV 050-0435. Field reconnaissance showed no mineralization or alteration in their vicinity. Unpatented claims in the Alunite and Sunset districts do not lie close to the WSAs. There are two small claim groups within the west side of WSA NV 050-0435.

WSA NV 050-0425 has very low favorability with very low confidence for metallic minerals, and has low favorability for uranium and thorium with a low level of confidence. Most of it has low favorability with low confidence for nonmetallic minerals, but parts around the edges have moderate favorability with moderate confidence for sand and gravel. Oil and gas and geothermal have low favorability with very low confidence.

All of WSA NV 050-0435 has very low favorability for metallic minerals, mostly with low confidence, but partly with very low confidence. All of it has low favorability for uranium and thorium at a low level of confidence. Part of it has low favorability with low confidence for nonmetallic minerals while the remainder has moderate favorability with moderate confidence for sand and gravel. About half of the WSA has low favorability for oil and gas with very low confidence, while the other half has very low favorability with very low confidence. The entire WSA has low favorability for geothermal resources with very low confidence.

I. INTRODUCTION

The McCullough Mountains G-E-M Resources Area (GRA No. NV-36) contains approximately 240,000 acres (980 sq km) and includes the following Wilderness Study Areas (WSAs):

WSA Name	WSA Number
North McCullough Mountains	NV 050-0425
McCullough Mountains	NV 050-0435

The GRA is located in Nevada within the Bureau of Land Management's (BLM) Stateline/Esmeralda Resource Area, Las Vegas district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 35°45' north latitude, 115° 5' west longitude and includes the following townships:

T 23 S, R 61-63 E	T 26 S, R 60-62 E
T 24 S, R 61,62 E	T 27 S, R 60-62 E
T 25 S, R 61,62 E	T 28 S, R 60-62 E

The areas of the WSAs are on the following U. S. Geological Survey topographic maps:

15-minute:

Sloan	McCullough Mountain

The nearest town is Jean which is located several miles west of the western GRA boundary on Interstate Highway 15. Access to the area is via Interstate 15 to the west, U. S. Highway 95 to the east and State Route 68 on the south. Access within the area is via unimproved dirt roads scattered throughout the GRA.

Figure 2 outlines the boundaries of the GRA and the WSAs on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin

and Range province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin Booth III and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

WSA NV 050-0435 in this GRA was field checked.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included in the GRA File to this report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

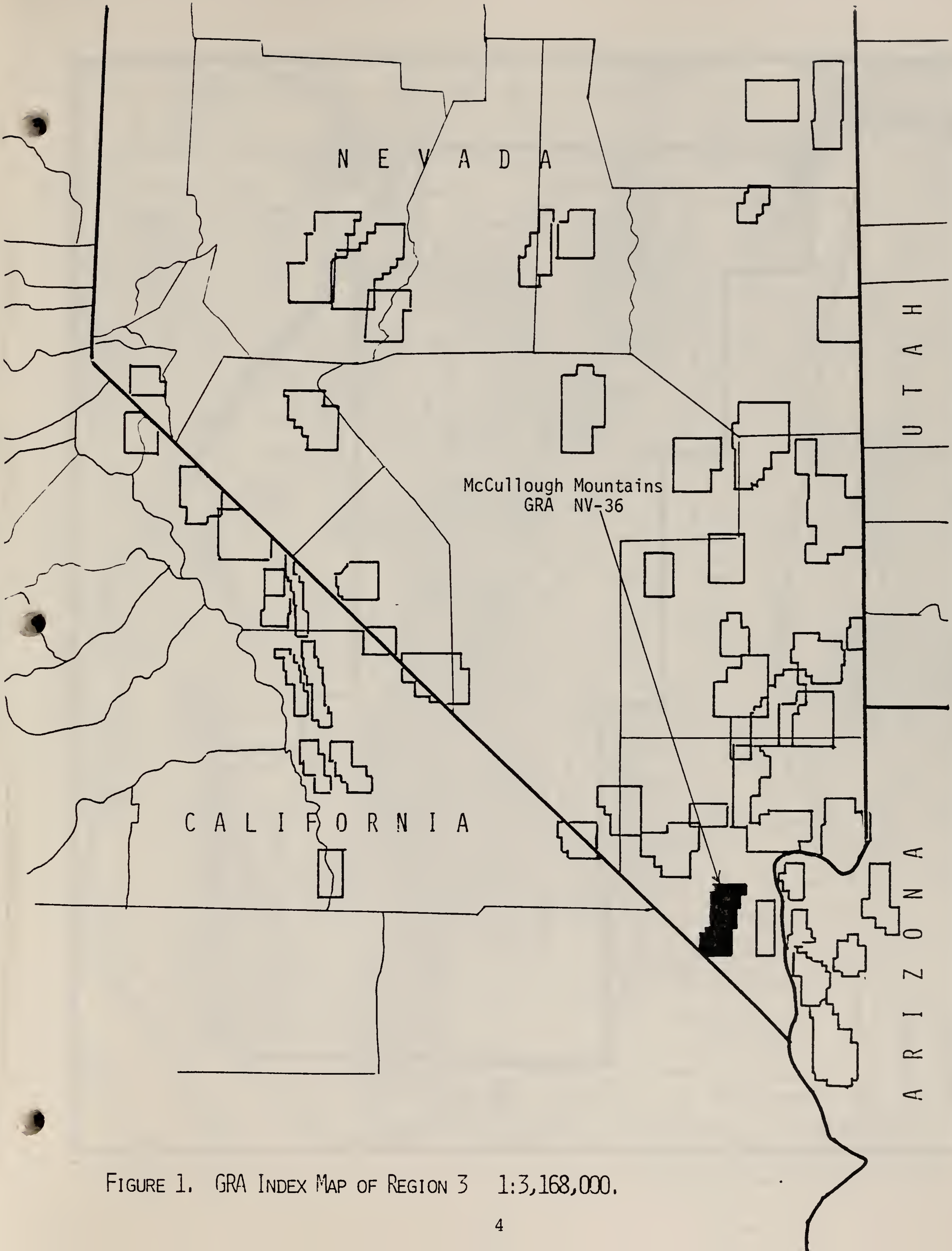
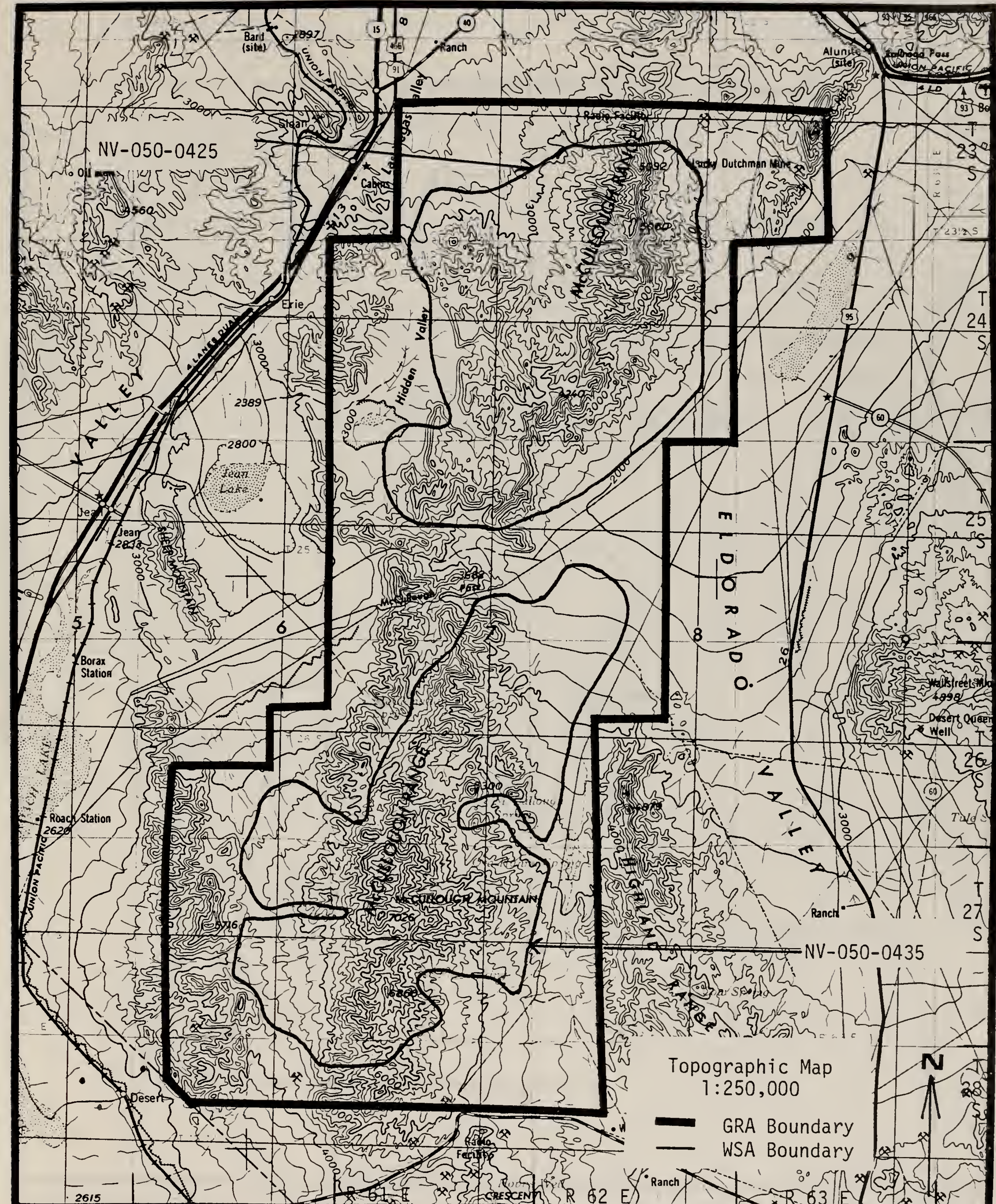


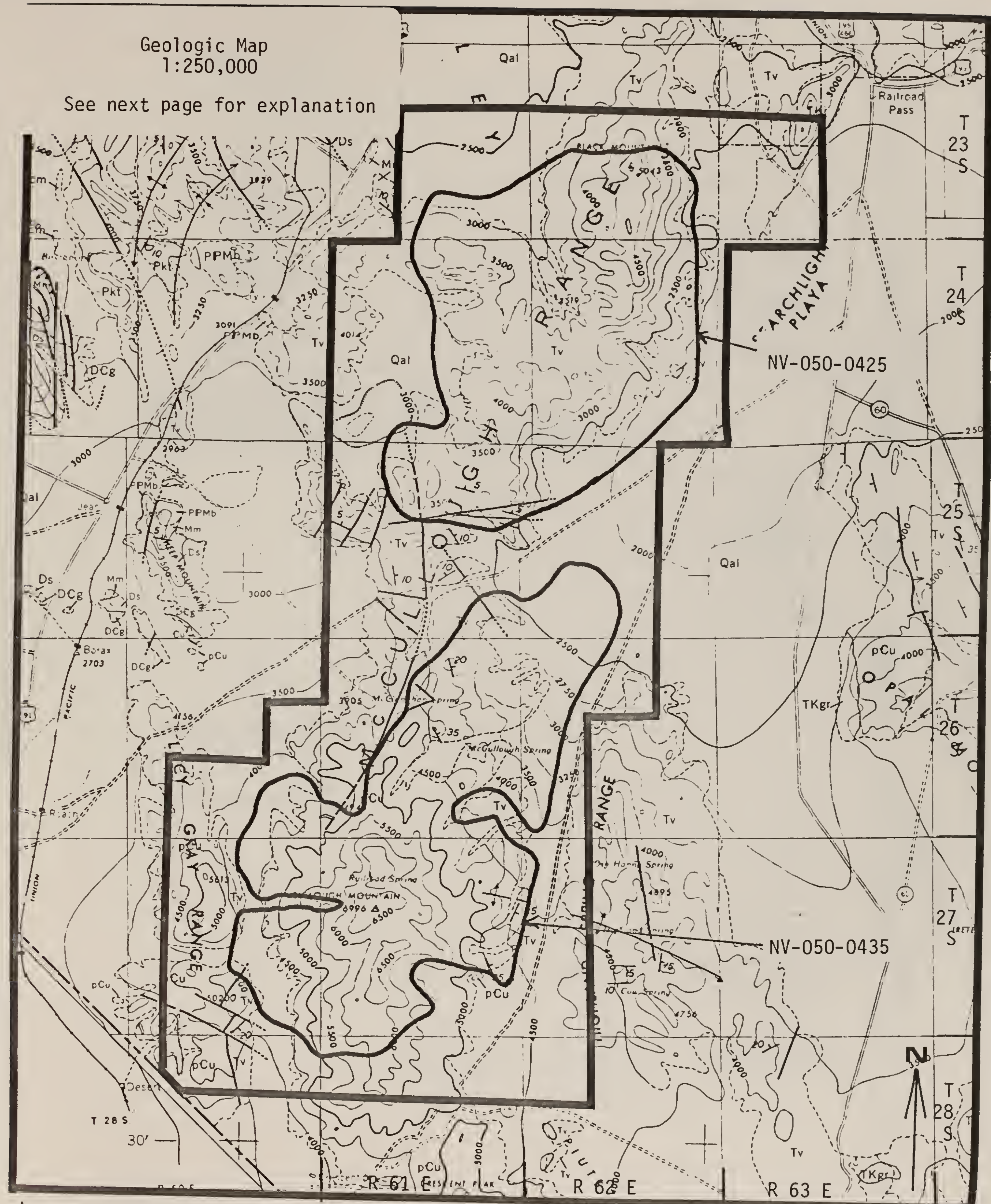
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Las Vegas Sheet

McCullough Mountains GRA NV-36

Figure 2



Longwell, Pampeyan, Bowyer
and Roberts (1965)

McCullough Mountains GRA NV-36

Figure 3

EXPLANATION

CLARK COUNTY

Qa

Alluvium

Qlv

Las Vegas Formation

UNCONFORMITY

Tv | Tb

Volcanic rocks

Tv, *undifferentiated volcanic rocks*
Tb, *Fortification Basalt Member of Muddy Creek Formation*

TKgr | TKi | TKc

Intrusive rocks

TKgr, *holocrystalline rock; mainly granite, quartz monzonite, granodiorite, and diorite*
TKi, *undivided porphyritic rocks. Includes granite porphyry, rhyolite, trachydolerite, and other intrusives ranging from basaltic to rhyolitic*
TKc, *undifferentiated intrusive rocks, mainly quartz monzonite and diorite containing roof pendants of volcanic rock, Paleozoic limestone and dolomite, and Precambrian rocks*

CRETACEOUS(?) AND TERTIARY

Ja

Aztec sandstone

Ŧcm

Chinle and Moenkopi Formations, undivided

EROSIONAL UNCONFORMITY

Pkt

Kaibab, Toroweap, and Coconino Formations, and red beds, undivided

Pzc

Paleozoic carbonate rocks, undifferentiated

Found only in Muddy Mountains

EASTERN CLARK COUNTY

TKg

Gale Hills Formation

Mapped only south of the Muddy Mountains

Kt

Thumb Formation

Mapped only northwest of Boulder Basin. May be correlative with lower part of Gale Hills Formation

Pzt

Remnants of thrust plate

Paleozoic rocks of Pennsylvanian to Cambrian age. Found only in North Muddy Mountains

QUATERNARY

Pliocene(?)

Tmc

Muddy Creek Formation

ANGULAR UNCONFORMITY

Ths

Horse Spring Formation

TERTIARY

TKo

Overton Fanglomerate

CRETACEOUS(?) OR TERTIARY(?)

CRETACEOUS(?)

ANGULAR UNCONFORMITY

Kbu | Kbl

Baseline Sandstone

Kbu, *upper member*
Kbl, *lower member*

Kwt

Willow Tank Formation

CRETACEOUS

ANGULAR UNCONFORMITY

TRIASSIC JURASSIC(?)

PERMIAN

PPMc

Callville Limestone

MISSISSIPPIAN PENNSYLVANIAN AND PERMIAN

Mr

Rogers Spring Limestone

MISSISSIPPIAN

MD

Rogers Spring Limestone and Muddy Peak Limestone, undivided

Grouped only in Frenchman Mountain

DEVONIAN AND MISSISSIPPIAN

CARBONIFEROUS

Dmp

Muddy Peak Limestone

Mapped only in Virgin and South Virgin Mountains

DEVONIAN

SILURIAN

ORDOVICIAN

WESTERN CLARK COUNTY

MISSISSIPPIAN, PENNSYLVANIAN AND PERMIAN / **CARBONIFEROUS**

PPMb

Bird Spring Formation

Lower and Upper Mississippian

Mm

Monte Cristo Limestone

DEVONIAN

Middle and Upper Devonian

Ds

Sultan Limestone

SILURIAN

Sl

Lone Mountain Dolomite

Found only in northern Spring Mountains and west of Dry Lake Valley

ORDOVICIAN

Lower, Middle, and Upper Ordovician

Oep

Ely Springs Dolomite, Eureka Quartzite, and Pogonip Group, undifferentiated

Eureka Quartzite, where present, shown as marker bed. Found only in northern Spring Mountains and west of Dry Lake Valley

CAMBRIAN TO DEVONIAN (?)

DCg

Goodsprings Dolomite

(Found only in the area west and southwest of Las Vegas)

CAMBRIAN

Middle and Upper Cambrian

Cdl

Dolomite and limestone, undivided

Lower and Middle Cambrian

Cq

Quartzite, shale, and limestone, undivided

Includes Tapeats Sandstone, Wood Canyon Formation, Pioche Shale, Lyndon Limestone, Chisholm Shale, and Carrara Formation

PRECAMBRIAN

pCsj

Stirling Quartzite and Johnnie Formation, undivided

UNCONFORMITY

pCu pCg pCm

Precambrian rocks

pCu, Precambrian rocks, undivided (mapped separately in the Virgin and South Virgin Mountains)

pCg, Gold Butte Granite of Longwell, 1936

pCm, gneiss and schist

II. GEOLOGY

The McCullough Mountains GRA lies in the Basin and Range province in southern Clark County, Nevada. The study area includes the Lucy Grey Range in the southwest corner of the GRA and the north-northeast-trending McCullough Mountains.

Precambrian gneissic granite is the predominant rock type in the southern half of the McCullough Mountains and the Lucy Grey Range. These basement rocks have been overlain by Tertiary latite, andesite, rhyolite and basalt flows and tuffs which dominate in the northern part of the range.

Although the deformational effects of the Cretaceous-Early Tertiary Sevier Orogeny thrust faulting are not recognized in this area, Early Tertiary granitic intrusives associated with the late phase of the Sevier Orogeny are found in the northeast corner of the study area and near Crescent Peak to the south. Broad warping, eastward tilting and Pliocene Basin and Range normal faulting have displaced the Precambrian and Tertiary rocks.

1. PHYSIOGRAPHY

The McCullough Mountains GRA lies in the Basin and Range Province in southern Clark County, Nevada. The study area includes the north-northeast-trending McCullough Mountains and the Lucy Grey Range in the southwest corner of the GRA.

The topography is characteristic of the Great Basin region. The McCullough and Lucy Grey Ranges are uplifted fault-bounded blocks composed of Precambrian gneiss and granite in the southern half and Tertiary volcanics in the northern half of the GRA.

Elevations along the crests of both ranges average about 5,000 feet, with the highest point of 7,026 feet at McCullough Mountain. Drainage is predominantly perpendicular to the trends of the ranges with the eastern slope of the McCullough Range draining into Eldorado Valley at about 2,000 feet elevation and the western slopes of the Lucy Grey and McCullough ranges draining into Ivanpah Valley at about 3,000 feet elevation. The western slope of the northern half of the McCullough range drains into Hidden Valley and Las Vegas Valley.

2. ROCK UNITS

The oldest rocks in the study area are unnamed Precambrian granites, granite-gneiss, and schist which are cut by later Precambrian pegmatite dikes and intrusives.

Gneissic granite is the predominant rock type in the southern half of the McCullough Mountains and the Lucy Grey Range. In the region east of McCullough Mountain narrow belts and lenses of Precambrian quartz-mica schist are either enclosed in or invaded by Precambrian gray granite. Both the granite and the belts of schist contain white pegmatite dikes composed largely of microcline and quartz. Northwest of Crescent the gray gneissic granite is intruded by lenses of coarse pinkish granite. Small masses of granite have also been intruded along the range crest south of Crescent Peak. These intrusive bodies near Crescent Peak have been interpreted by Longwell and others (1965) as being of Tertiary age, but Bingler and Bonham (1972) consider them to be Crutaceous.

In the northeast corner of the study area west of Railroad Pass an earlier Tertiary granitic mass outcrops surrounded by younger Tertiary volcanics. As mentioned above, granitic intrusives in the Crescent Peak area may be of Tertiary age also (Longwell and others, 1965).

For a distance of 12 miles on the lower east slopes of the McCullough Range the granite gneiss is overlain by a thick unnamed series of basal Miocene sand and gravel and andesitic breccia tuffs and flows. A similar unnamed sequence lies along the eastern flank of the Lucy Grey Range. In this area the beds strike N 25°W and dip 35°E parallel to the contact of the underlying granite gneiss. Based on the correlation of these Tertiary volcanics and sediments on the eastern flanks of the Lucy Grey Range and the Southern McCullough Mountains it is postulated that the Lucy Grey Range has been downdropped about 20,000 feet along a normal fault (Hewett, 1956).

The entire northern half of the study area is blanketed with a Tertiary sequence of basal gravels and latite flows, andesite and rhyolitic flows, breccias and tuffs, and a basalt capping. In the Black Mountain area these volcanics reach a maximum thickness of 3,200 feet. It is suggested by Hewett (1956) that the Black Mountain volcanics were derived from easterly sources and filled up a great depression that extended northward.

East of Erie in the northwest corner of the study area lies a semi-circular ridge of Tertiary latite flows. The source of these flows is probably the same as that which yielded the basal latite flows of Black Mountain.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures in the study area are preserved in the metamorphosed Precambrian granite-gneiss and schists. The foliation of these rocks generally trends northeast and dips to the northwest. Locally the rocks are contorted into northeast-trending folds. Most of the deformation of the Precambrian rocks occurred during the Precambrian.

The deformational effects of the Cretaceous-early Tertiary Sevier Orogeny thrust faulting are not found in this area. However, Early Tertiary granitic intrusives associated with the late phase of the Sevier Orogeny are found in the northeast corner of the study area and near Crescent Peak to the south.

Subsequent to the Middle Tertiary deposition of sediments and volcanics, broad warping, eastward tilting and Pliocene Basin and Range normal faulting occurred. Large scale north-south-trending normal faults bound the Lucy Grey Range. The McClanahan hinge fault in the central portion of the study area is a convex eastward arc whose displacement in the north is small but increases to about 1,200 feet at McClanahan Spring to the south.

Small normal faults occur in the central region of the GRA and the southeast flank of the Lucy Grey Range. Trends of these faults are predominantly northwest and northeast. Recent movement along these faults has not been documented.

Faulting in the northern half of the study area is very minor, and is confined to the eastern flank of the range where several small northeast trending normal faults are located.

4. PALEONTOLOGY

This geological resource area has virtually no potential for paleontological resources. Younger rocks are Tertiary volcanics which comprise the majority of the northern part of the area and are mostly andesites. Precambrian metamorphic rocks (Stewart and Carlson, 1978) are the dominant lithology of the southern part of the GRA. The only possibility for paleontological resources would reside within the older Quaternary to latest Tertiary alluvium, which is considered unlikely for this area.

5. HISTORICAL GEOLOGY

During the Precambrian existing sediments, volcanics and intrusives were metamorphosed and intruded by later Precambrian granitic masses and pegmatite dikes. Paleozoic and Mesozoic sediments may have been deposited in the area, but were removed by pre-Tertiary periods of erosion subsequent to Sevier Orogeny overthrusting and igneous activity.

Early Tertiary granitic bodies related to the late phase of the Sevier Orogeny were emplaced west of Railroad Pass and in the Crescent Mountain area.

During the Middle Tertiary, possibly in Late Miocene, sediments and volcanics were deposited in a north-trending basin in the northern half of the GRA.

Late in Tertiary time the entire region was involved in an epoch of deformation. Broad warping was followed by Pliocene Basin and Range normal faulting and tilting. The uplifted blocks of the McCullough Mountains and Lucy Grey Range have been modified by erosional processes to their present physiography.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There are three mining districts in the GRA -- two in the southern part of the GRA, along the southern border of WSA NV 050-0435, and the other in the northeast corner.

The largest and most important district is the Crescent district which was activated in 1894 with the discovery of turquoise. Gold, silver, lead and minor copper were produced up until 1941 when the district became inactive. The majority of the district lies south, outside the GRA. The Double Standard mine in Sec. 31 of T 27 S, R 61 E is just outside the south boundary of WSA NV 050-0435 and reportedly produced several thousand dollars worth of gold and silver from quartz leases containing galena, tetrahedrite and chalcopyrite in shear zones in Precambrian granite gneiss (Longwell and others, 1965). Vinnie Bressi, a local prospector encountered during field verification, states that the Double Standard mine is in Sec. 18, T 28 S, R 61 E.

Another district is the Sunset (Lyons) district in the Lucy Grey Range in the southwestern part of the GRA. The only productive property in the district is the Lucy Grey mine in Sec. 32, T 27 S, R 60 E. Total production from the mine is estimated at $50,000, principally in gold with lesser amounts of silver, lead and copper. The majority of the production was between 1905 and 1928. The ore is concentrated in secondary fractures which cut quartz veins cementing a breccia pipe in Precambrian gneiss (Vanderburg, 1937).

In the northeastern portion of the GRA and to the east of WSA NV 050-0425 the Alunite or Railroad Pass district produced a limited amount of gold from the Quo Vadis mine in T 23 S, R 63 E. Gold and silver was produced in 1935 and 1936 from quartz veinlets in sheared andesite. In some parts of the district there is some silicification and alunitization in andesitic volcanic rocks.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

The only known occurrences, prospects and mineralized areas are those associated with the above three mining districts.

3. Mining Claims

The majority of the unpatented mining claims in the GRA are lode claims found to the south which are in the Sunset and Crescent mining districts. Some of the claims extend into the southern portion of WSA NV 050-0435. There are a few scattered claims well within the same WSA, apparently in the same gneiss unit which hosted the Double Standard and Lucy Grey mines to the south, but their reason for being staked is unknown.

Field verification on December 13 and 14, 1982, was aimed at determining the nature of mineralization at the south end of WSA NV 050-0435 in the area of rather extensive staking that constitutes a northern extension of the Crescent district. This disclosed little of interest. Virtually no mineralization or alteration is to be seen. Old bulldozing in the vicinity of the prospect symbol in the SE 1/4 of Sec. 4, T 28 S, R 61 E (McCullough Mountain 15-minute topographic quadrangle) may have been done in the 1950s for uranium -- there is no evidence of any kind of mineralization in the gneiss exposed in the cuts and in natural outcrops. The site of the shaft symbol in the NE 1/4 Sec. 11, T 28 S, R 60 E has been bulldozed out, exposing an andesite dike striking north and dipping about 50° west, and four feet wide. In the dike are seams of calcite up to two inches wide that perhaps contain some gold -- they are the only evidence of mineralization. There is no alteration. The dike is the only rock seen in the area that is not intensely metamorphosed; it may well be of Tertiary age. There are several other bulldozer cuts within a quarter-mile radius of this cut but none of them disclose mineralization. All appear to be only a couple of years old.

In Sec. 32, T 27 S, R 61 E and Sec. 5, T 28 S, R 61 E a well-constructed four-strand barbed wire fence with steel posts extends along the divide of the range at least from Hill 6631 to Hill 6331. Whether it extends northward beyond Hill 6631 into WSA NV 050-0435 is not known.

To the north there are claims in the Alunite district but none of these extend into WSA NV 050-0425.

The only patented claims in the GRA are at the south end in the Crescent district. There are no patented claims in either WSA.

4. Mineral Deposit Types

The Crescent and Sunset mining districts are narrow vein type gold and silver deposits associated with quartz in Precambrian gneiss. The Alunite district to the north produced gold and silver from quartz veinlets in sheared andesite.

5. Mineral Economics

Small, narrow sporadic veins are generally not attractive as a mining target to major mining companies. The deposits in the GRA showed only minor production and from what is reported in the literature the mineralization is confined to the sporadic small veins. Perhaps areas of more disseminated mineralization or even high grade ore shoots could be found making it more economical. A small operation could possibly mine one of the veins underground if enough ore were to be blocked out. The Crescent district was the subject of intense exploration for porphyry copper despoits in the 1960s, but all of this activity was well south of the WSAs (personal communication, Arthur Baker III).

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

There is one known nonmetallic deposit in production in the GRA and that is a lightweight aggregate producer in Sec. 9, T 25 S, R 61 E, just west of the southwestern boundary of WSA NV 050-0425. The mine is in a siliceous pumiceous volcanic tuff breccia unit associated with perlitic rhyolite to dacite flows. The deposit was found in 1975 and has been in production since 1979.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Alunite is found in the Railroad Pass district in altered volcanic rocks. These altered volcanic rocks, however, are just outside the GRA on the northeast.

Feldspar is found in pegmatite dikes which cut the Precambrian rocks in the southern McCullough Range near the Crescent and Sunset mining districts. No feldspar is known to have been produced from these occurrences in the GRA however.

Barite is found as a minor accessory mineral in some veins in the Crescent district and the Alunite district.

No other nonmetallics are known to exist in the GRA.

3. Mining Claims, Leases and Material Sites

The only unpatented mining claims known to have been staked for nonmetallics are those which were located for the lightweight aggregate and perlite deposit described above.

There are no other known nonmetallic mining claims in the GRA or the included WSAs.

4. Mineral Deposit Types

The lightweight aggregate deposit is volcanic tuff breccia containing fragments of pumiceous rhyolite.

Feldspar is in pegmatite dikes cutting the Precambrian gneisses in the southern part of the GRA.

5. Mineral Economics

The lightweight aggregate deposit is currently in production and furnishes material for lightweight concrete and lightweight concrete masonary units in the Las Vegas area. It is the closest lightweight aggregate deposit to the Las Vegas market.

The feldspar deposits economics are unknown because their size and grade are unknown. One similar feldspar deposit outside the GRA to the south produced 1,000 tons of feldspar prior to 1936 (Longwell and others, 1965).

For statistical purposes pumice, volcanic cinder and scoria are treated together because in most applications they are interchangeable; the word "pumice" as used here includes the other materials. Because of its porous nature and resultant light weight (some pumice will float on water) about 40 percent of all pumice production is used as aggregate in making light-weight concrete for construction purposes. An equal amount is used as aggregate in road construction. A small amount is used in abrasives, while the remainder is used, mostly in finely-ground form, in a multitude of applications such as absorbents, carriers for insecticides, decolorizers and purifying agents, fillers and extenders for paints, and many others. United States consumption is about 4.5 million short tons annually, nearly all of which is produced domestically and most of which is produced within a very few hundred miles of the point of use because it is a high-volume, low-unit-price material. A small quantity of pumice for specialized uses is imported. United States demand for pumice is forecast to more than double by the year 2000, with domestic production keeping up with demand. In the recent years the F.O.B. mine price for pumice as such has been about $4 per ton, while the price for the somewhat more common volcanic cinders has been about $3 per ton.

Nearly all feldspar is used in either glassmaking or the ceramic industry but small amounts are used as a powdered abrasive, frequently in household applications. The

United States produces nearly three-quarters of a million short tons annually and uses a little less than this, the remainder being exported. United States consumption is forecast to increase to well over one million tons by the year 2000, with domestic production supplying all or most of this. Feldspar is a very common mineral everywhere in the world, and the only reason for any increase in imports into the United States will be lower foreign production costs. The price of feldspar F.O.B. mine is about $30 per ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

   There are no known uranium or thorium deposits in the WSAs or the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

   There are no known thorium or uranium occurrences within the WSAs. However, there is one radioactive occurrence in the southwestern part of the GRA at the Lucy Grey mine, SE 1/4, Sec. 32, T 27 S, R 60 E, where anomalous radioactivity is associated with iron and copper oxides in a breccia pipe in Precambrian granite gneiss (Garside, 1973). Radioactive occurrences are indicated on the Uranium Land Classification and Mineral Occurrence Map at the back of the report. Several other occurrences are present just south of the GRA in the Crescent mining district (Garside, 1973). The radioactive occurrences are present in rocks similar to those exposed in the southern half of the GRA and in WSA NV 050-0435. These occurrences are tabulated below:

Name and Location	Description
Samples (3) Sec. 17, 21, 22 T 28 S, R 61 E	Anomalous thorium and/or uranium in Precambrian mylonitic augen gneiss and quartz monzonite
Nippeno mine Sec. 22 & 27 T 28 S, R 61 E	Allanite-like mineral in aplitic dike which cuts Precambrian rocks

Surprise group Sec. 29(?) T 28 S, R 61 E	Anomalous radioactivity in area of Precambrian gneiss with granitic dikes. Base metal quartz veins in nearby mines.
Thor claims Sec. 32 T 28 S, R 61 E	Monazite-allanite alteration in Tertiary or Cretaceous quartz monzonite
Prospectors Uranium claims (Nos. 1-20) Secs. 3, 10 T 29 S, R 61 E	Apatite-monazite-rich dike cutting granitic rocks
Yellow Jacket grp. (Nos. 1-15) Sec. 7 T 26 S, R 60 E	Shear zone with autunite cuts Precambrian red granite.

3. Mining Claims, Leases and Material Sites

There are numerous claims in the southern and southwestern portions of the GRA and some extend into the southern part of WSA NV 050-0435. Many of these claims are in the Crescent and Sunset mining districts, and it is not known whether any of the current claims are for uranium. The claims noted above occur to the west, southwest and south of the GRA.

4. Mineral Deposit Types

Deposit types cannot be discussed due to the lack of uranium and thorium occurrences.

5. Mineral Economics

Uranium and thorium do not appear to occur in economic quantities in the WSAs or the GRA. The occurrences noted above are probably too small and scattered to be mineable.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a by-product of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced

from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear power reactor usage, assuming that six to ten thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequacy of thorium reserves. The United States has reserves estimated at 218,000 tons of ThO in stream and beach placers, veins and carbonatite deposits (Kirk, 1982); and probably cumulative demand in the United States as of 2000 is estimated at only 1,800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate.

Oil and Gas Resources

1. Known Oil and Gas Deposits

   There are no known oil and gas deposits in the GRA.

2. Known Prospects, Oil and Gas Occurrences and Petroliferous Areas

   There are no known oil seeps in the GRA. The Oscar Bray No. 1 (840' TD, 1961) (Locality #1 on the Oil and Gas Occurrences and Land Classification Map) was drilled in the southeast corner of the GRA. Wells in the immediate area, but outside the GRA boundary are (Lintz, 1957; Schilling and Garside, 1968; and Nevada Bureau of Mines and Geology, 1982):

   (#2) Black Gold Oil & Gas Exploration Co., Golden Spike No.1
   950' TD, 1950

   (#2) Intermountain Assoc. Arden Dome, No. 1X
   3293' TD, 1954

   (#3) Intermountain Assoc., Jean No. 1
   2273' TD, 1954

   (#4) Sandia, Duff No. 1
   438' TD, 1971

   (#5) Fleetwood Oil & Gas, GER No. 1
   933' TD

   (#6) Fleetwood Oil & Gas, Eva Garten No. 1
   2850' TD

   (#7) Leonard Wilson, Government No. 1
   810' TD, 1953

   (#7) Leonard Wilson, Government No. 1A
   1466' TD, 1953

3. Oil and Gas Leases

   In WSA 050-435 there are at least 12 square miles of leases and nearly every section of WSA 050-0425 is leased.

4. Oil and Gas Deposit Types

Oil deposits that have been found and developed, and those that are being explored for in the Basin and Range to date, have been limited to the Upper Paleozoic section of the Miogeosyncline and the Tertiary section of the intermontane basins. The source rocks are assumed to be in Paleozoic horizons, such as the Mississippian Chainman Shale, and perhaps also the Tertiary section.

The reservoirs at the Trap Spring and Eagle Springs oil fields in Railroad Valley are the Oligocene Garrett Ranch volcanics or equivalent, which produce from fracture porosity; or the Eocene Sheep Pass Formation, a freshwater limestone. Minor production has been recorded from the Ely(?) Formation of Pennyslvanian age at Eagle Springs. It may be that production also comes from other units in the Tertiary or Paleozoic sections in the Blackburn oil field in Pine Valley or the Currant and Bacon Flat oil fields in Railroad Valley.

The GRA is within or close to the North American Overthrust Belt which has good oil and gas production in Wyoming/Utah, Mexico and Canada (Oil and Gas Jour., May 12, 1980). The Federal leases in Nevada are for rank wildcat acreage, and surficial stratigraphic units do not necessarily have a direct bearing on possible drilling objectives at depth, considering overthrust structural implications.

Recent seismic surveys (e.g., Seisdata Services, 1981; Geophysical Service Inc., 1981; GeoData, 1981: Index maps in GRA File) indicate, in part, the general area of industry interest. This and certain other data may be purchased, but deep exploratory test data are not readily available. Published maps of the Overthrust Belt in Nevada are very generalized, and are not necessarily in agreement because exploration is at an early stage (Oil and Gas Jour., May 12, 1980; Western Oil Reporter, June, 1980; Keith, 1979: Index maps in GRA File).

5. Oil and Gas Economics

The low level of production from Nevada Basin and Range oil fields, which are remote from existing pipelines, existing refineries and consuming areas, necessitates the trucking of the crude oil to existing refineries in Utah, California and Nevada. Since the discovery of oil in Nevada in 1953, the level of production has fluctuated. Factors which have affected the production from individual wells are: reservoir and oil characteristics; Federal regulations; productivity; environmental constraints; willingness or ability of a refiner to take certain types of oil; and of course, the price to the producer, which is

tied to regional, national and international prices.

Geothermal Resources

1. Known Geothermal Deposits

   There are no known geothermal deposits in the GRA.

2. Known Prospects, Geothermal Occurrences, and Geothermal Areas

   There are no known prospects, occurrences or thermal areas in the WSA, but just outside the GRA is to the east and west are two wells with temperatures of 83°F and 81°F, respectively (Garside and Schilling, 1979). These are barely in the thermal water category at this latitude and elevation.

3. Geothermal Leases

   There are no leases on Federal lands in the GRA or vicinity.

4. Geothermal Deposit Types

   Geothermal resources are hot water and/or steam which occurs in subsurface reservoirs or at the surface as springs. The temperature of a resource may be about 70°F (or just above average ambient air temperature) to well above 400°F in the Basin and Range province.

   The reservoirs may be individual faults, intricate fault-fracture systems, or rock units having intergranular permeability -- or a combination of these. Deep-seated normal faults are believed to be the main conduits for the thermal waters rising from thousands of feet below in the earth's crust.

   The higher temperature and larger capacity resources in the Basin and Range are generally hydrothermal convective systems. The lower temperature reservoirs may be individual fautls bearing thermal water or lower pressured, permeable rock units fed by faults or fault systems. Reservoirs are present from the surface to over 10,000 feet in depth.

5. Geothermal Economics

   Geothermal resources are utilized in the form of hot water or steam noramlly captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The

fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year-round mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is an historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

There are no other known geological resources in the GRA or the WSAs. There is no potential for coal.

E. STRATEGIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

Silver was the most important strategic and critical mineral

produced from all three mining districts within the GRA. Minor amounts of lead and copper were also produced.

IV. LAND CLASSIFICATION FOR G-E-M RESOURCES

The geologic map of Longwell and others (1965) indicates that the northern part of the McCullough Range is covered with Tertiary volcanics, with Quaternary alluvium in the valleys. For the southern part of the Lucy Grey Mountains the map of Bingler and Bonham (1972) subdivides the Tertiary volcanics into two units and the Precambrian rocks into several units, but nonetheless it is quite generalized. There is little data concerning mineral occurrences and prospects, perhaps because there are few occurrences or prospects. The quantity of geological data available is low, and its quality is low also. The quantity of data concerning mineral occurrences or potential is very low, while its quality is low to moderate. The overall level of confidence in the data available is low.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g., M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C, and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside a WSA has been used in establishing a classification area within a WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA NV 050-0425

M1-1A. This classification area covers most of the WSA. In it the outcropping rocks are undifferentiated Tertiary volcanics (Longwell, 1965). These rocks are altered and mineralized elsewhere in the region, as at Alunite northeast of the GRA and Eldorado Canyon east of it, but no alteration or mineralization is known in them in the GRA. The nature of the rocks beneath the volcanics is not known. The apparent total lack of mineralization in the volcanic rocks is the reason for the very low favorability, while lack of information about the exposed rocks and the possibility of older mineralization in the rocks beneath them is the reason for the lack of confidence in this classification.

M8-1A. This classification area covers an irregular strip along the eastern edge of the WSA. In it there are no outcrops, only Quaternary alluvium. Presumably the adjacent Tertiary volcanic rocks underlie the alluvium, and older rocks lie at still greater depth. There is no evidence of mineralization, which is the reason for the very low favorability, but the possibility for deposits in the rocks beneath the alluvium causes a very low level of confidence in this classification.

M7-1A. This classification area covers parts of the west side of the WSA. Quaternary alluvium is exposed, and the reasoning for the classification and the level of confidence is the same as for M8-1A.

WSA NV 050-0435

M1-1A. This classification area covers that part of the north end of the WSA in which Tertiary volcanics are exposed. The reasoning for the classification and the level of confidence is given above under WSA NV 050-0425.

M2-1A. This classification area covers part of the east side of the WSA where Tertiary volcanics are exposed. The reasoning for the classification and level of confidence are the same as for M1-1A.

M3-1A. This classification area covers a small area at the west edge of the WSA in which the Tertiary volcanics are exposed. The reasoning for the classification and the level of confidence is the same as for M1-1A.

M4-1A. This classification area covers another small area at the west edge of the WSA in which the Tertiary volcanics are exposed. The reasoning for the classification and the level of confidence is the same as for M1-1A.

M5-1B. This classification area covers much of the WSA. In it Precambrian gneisses are exposed and there are no post-metamorphism intrusive rocks. No mineralization is known in the gneisses of the WSA. The mineralization in the Crescent district to the south is partly in these rocks but is evidently related to a Cretaceous stock that intrudes them. The very low favorability stems from the lack of known mineralization, and the low level of confidence stems from the lack of intrusives that might cause mineralization.

M6-1B. This classification area covers very small parts of the western edge of the WSA in the Lucy Grey Mountains. The rock is the same gneiss as in M5-1B, and the rationale behind the classification and level of confidence is the same as for M5-1B.

M7-1A. This classification area covers a strip along the west side of the southern half of the WSA. Quaternary alluvium is present throughout, and the rationale for the classification and level of confidence is the same as for M8-1A.

M8-1A. This classification area covers areas along the east side of the WSA in which Quaternary alluvium is exposed. The rationale for the classification and the level of confidence is given above under WSA NV 050-0425.

b. Uranium and Thorium

WSA NV 050-0425 and WSA NV 050-0435

U1-2B. This classification covers most of WSA NV 050-0425, a part of the northeastern portion of WSA NV 050-0435 and small areas in the northern part of the GRA. This area is covered by Tertiary volcanic rocks including rhyolites and tuffs. The area has low favorability for uranium as fracture fillings in the volcanics at a low level of confidence. There are no known uranium occurrences in these volcanics in the area.

The area has low favorability with very low confidence for thorium deposits in Precambrian gneisses and pegmatites which may underlie the Tertiary volcanics.

WSA NV 050-0435

U2-2B. This classification covers the southwest portion of WSA NV 050-0435 and small areas in the southern part of the GRA. The area is characterized by Precambrian gneissic granite, schist and local pegmatite. This area has low favorability for uranium in fracture fillings, breccia pipe or pegmatite deposits. The presence of anomalous radioactivity in a breccia pipe (Lucy Grey mine) and in granitic gneisses, just south of WSA NV 050-0435, demonstrates the potential for these types of occurrences in this area.

The area has low favorability with a low level of confidence for thorium in pegmatites or gneisses.

WSA NV 050-0425 and WSA NV 050-0435

U2-3B. This land classification includes small areas of WSA NV 050-0425 and WSA NV 050-0435 which are covered by Quaternary alluvium. These areas have low favorability with a low level of confidence for uranium in epigenetic sandstone-type deposits. Uranium from rhyolitic volcanics in the north and granitic gneisses or pegmatites in the south may have been leached by ground water and deposited in reduced areas in the alluvium. The gneisses and granites are probably better uranium sources than the rhyolites in the area, because they are known to be anomalously radioactive south of WSA NV 050-0435.

The southwest portion of WSA NV 050-0435 has low favorability with a low confidence level for alluvial thorium deposits. Monazite, weathered from the gneisses and pegmatites of the area, may have been concentrated as placer deposits in the alluvial fans on the west side of the McCullough Range. The northeast corner of WSA NV 050-0435 has less favorability for this type of thorium occurrence because the gneisses are covered by Tertiary volcanics in that area. Small areas in WSA NV 050-0425 covered by alluvium would not be prospective for thorium due to the lack of granite or pegmatite exposures in the source areas for the alluvium.

c. Nonmetallic Minerals

WSA NV 050-0425

N1-2B. This classification area covers most of the WSA in which the undifferentiated volcanic rocks are exposed. No occurrences of nonmetallic minerals are known in these rocks, any rock may be made into an economic commodity by someone who can come up with a use for it; this is the reason for the low favorability and low confidence.

N3-3C. This classification area covers a narrow strip along part of the east edge of the WSA in which Quaternary alluvium is exposed. The alluvium by definition contains sand and gravel, which is the reason for the moderate favorability classification. The quality of the sand and gravel at any given point is unknonw, which is the reason for the only moderate confidence in the classification.

N4-3C. This classification covers parts of the west side of the WSA in which Quaternary alluvium is exposed. The rationale for the classification and level of confidence is the same as for N3-3C.

WSA NV 050-0435

N2-2A. This classification area covers much of the WSA in which Precambrian gneiss is exposed. Pegmatite bodies containing feldspar and quartz are common in the gneiss. The potential for feldspar production from these bodies is the reason for the low favorability. The lack of information about size or exact composition of the bodies, and the possibility of any rock becoming an economic nonmetallic commodity, are the reasons for the low level of confidence.

N3-3C. This classification area covers the northeastern part of the WSA in which Quaternary alluvium is exposed. The rationale for the classification and confidence level is given under WSA NV 050-0425, above.

N4-3C. This classification area covers a strip along the western part of the WSA in which Quaternary alluvium is exposed. The rationale for the classification and the level of confidence is given under WSA NV 050-0425, above.

2. LEASABLE RESOURCES

a. Oil and Gas

WSAs NV 050-0425 and NV 050-0435

OG1-2A. There have been at least eight shallow (438 to 3,293-foot) exploratory wells drilled in the immediate area of the WSAs. All have been drilled in the valleys where source and reservoir rocks may be present -- depending upon the specific location. There have been no commercial successes to date, but the Arden Dome No. 1 (#2), GER No. 1 (#5) and Eva Garten No. 1 (#6) are known to have had oil and gas shows. Portions of both WSAs are expected to be structurally and stratigraphically similar to these well locations.

Although Precambrian and Tertiary volcanic rocks underlie most of the WSAs, industry mapping includes this region within the Overthrust Belt, which implies the possibility that the Precambrian in outcrops may be rootless. If this is so, then there may be drilling objectives beneath the WSAs at depth. There is no readily available drilling or geophysical data to support this thinking in the immediate area of the WSAs.

OG2-1A. This classification incorporates the main mass of the McCullough Range, not under lease, which is underlain by a Precambrian section. Source and reservoir rocks are highly unlikely to be present unless the range is "rootless" as described above under OG1-2A.

b. Geothermal

WSAs NV 050-425 and NV 050-435

G1-2A. The southern part of the Nevada portion of Basin and Range Province is host to mostly low-temperature resources. The geologic map shows the presence of some extensive deep-seated faulting, normally a prerequisite for geothermal occurrences in the State. Further, the "thermal" wells cited in Section III, indicate the presence of a heat source beneath the area.

c. Sodium and Potassium

WSAs NV 050-425 and NV 050-435

S1-1D. The geology of the GRA is such that there is very low favorability for sodium and potassium resources, with a high level of confidence. No map is presented for sodium and potassium.

3. SALEABLE RESOURCES

Saleable resources have been covered above under Nonmetallic Minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

Very little is known about either the geology of the McCullough and Lucy Grey Ranges, or about mineral occurrences in them. As a minimum a stream sediment geochemical sampling program should be undertaken, followed up with reconnaissance to determine the source of any anomalies found. If good color aerial photography is available, this should be examined in detail in an effort to identify altered areas (if present) by color differences; and if any are found, they should be examined and sampled in the field.

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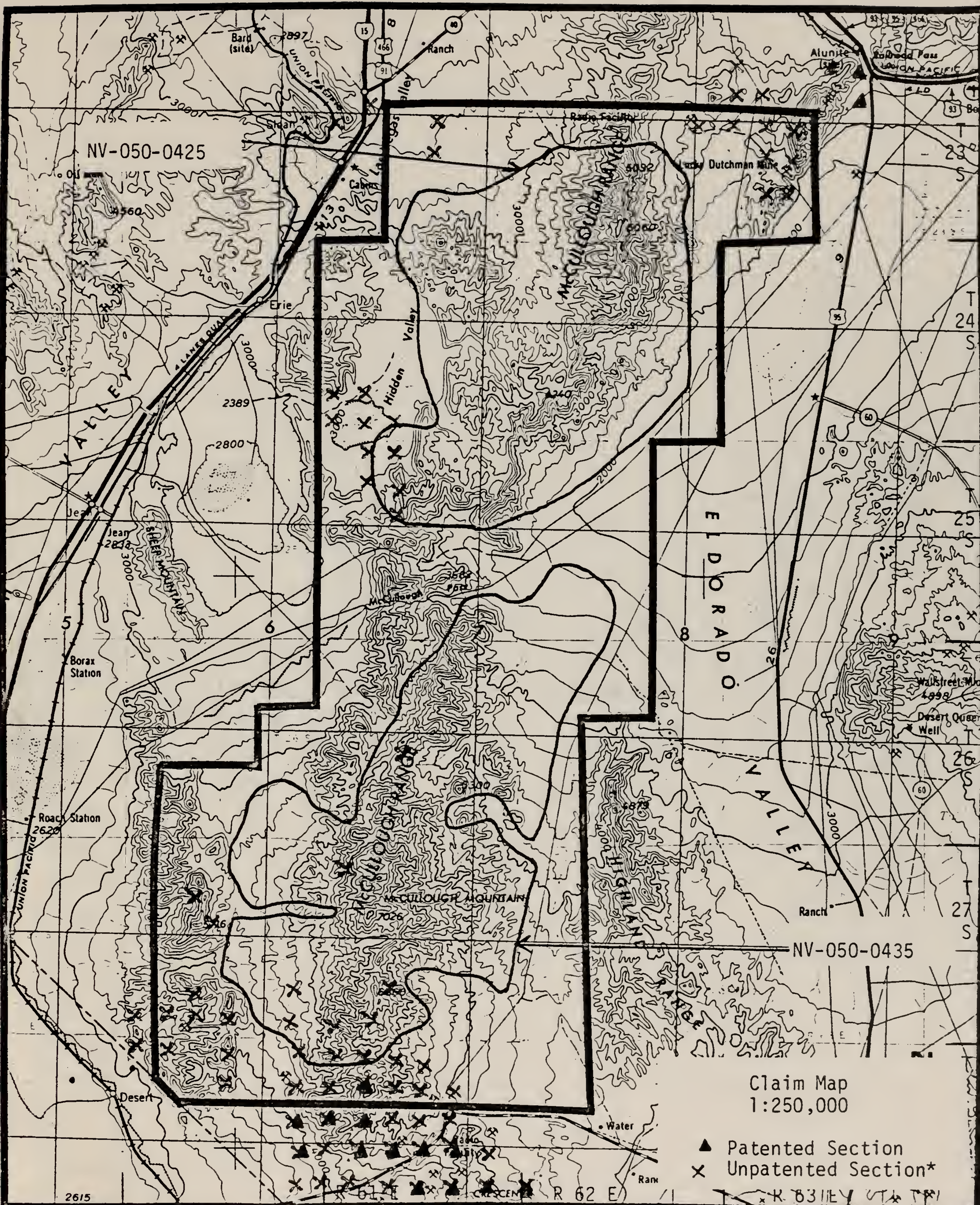
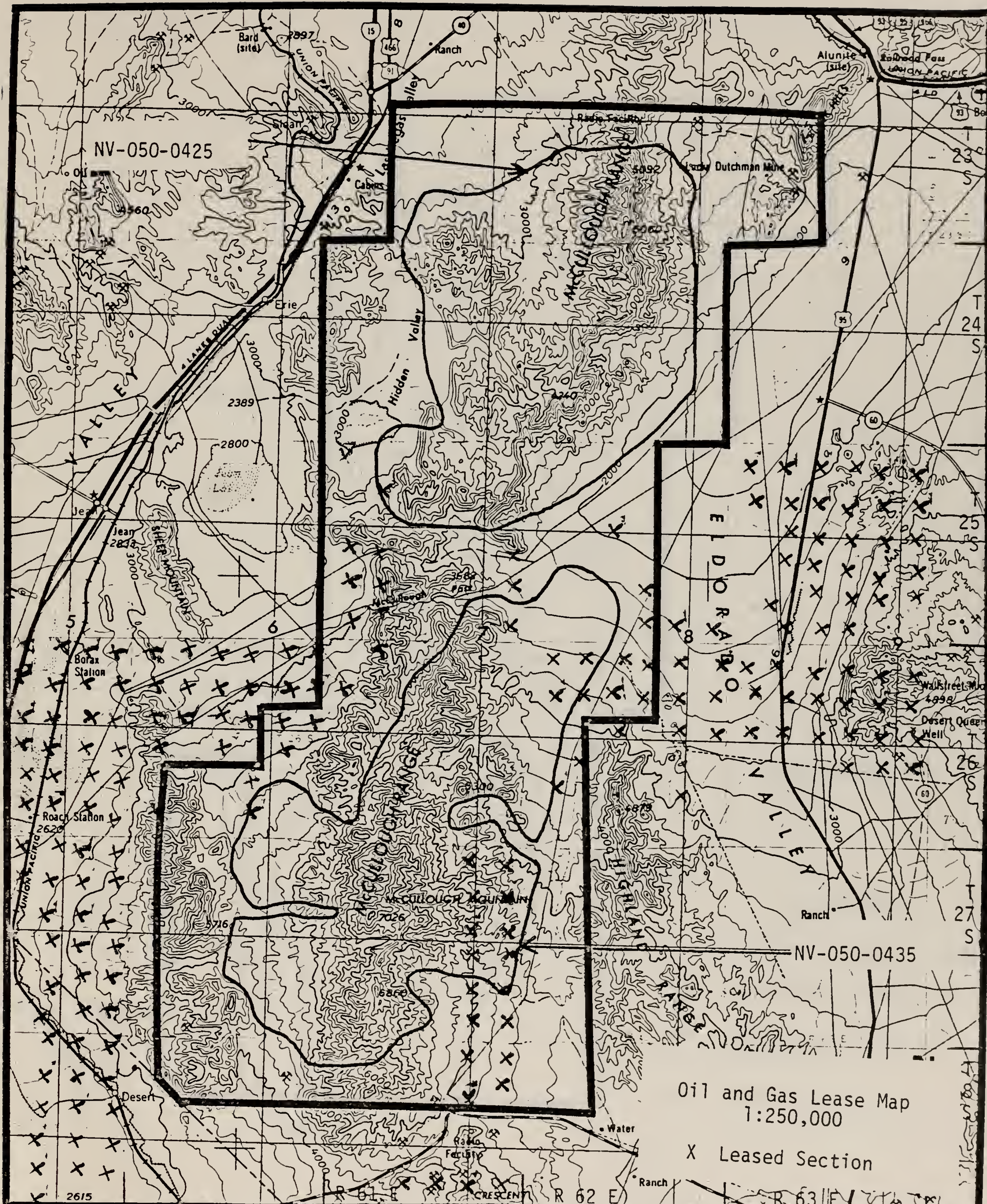
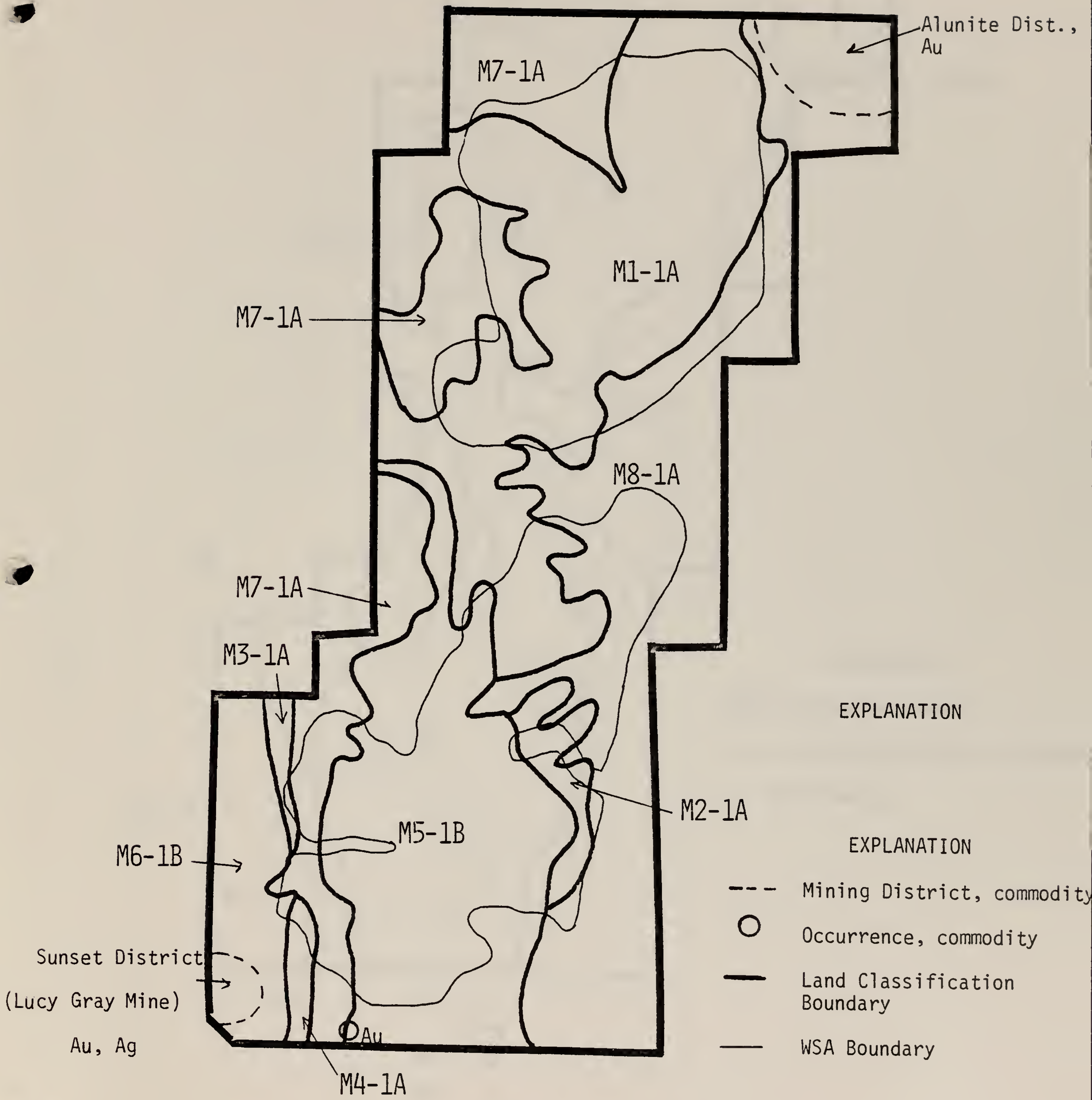
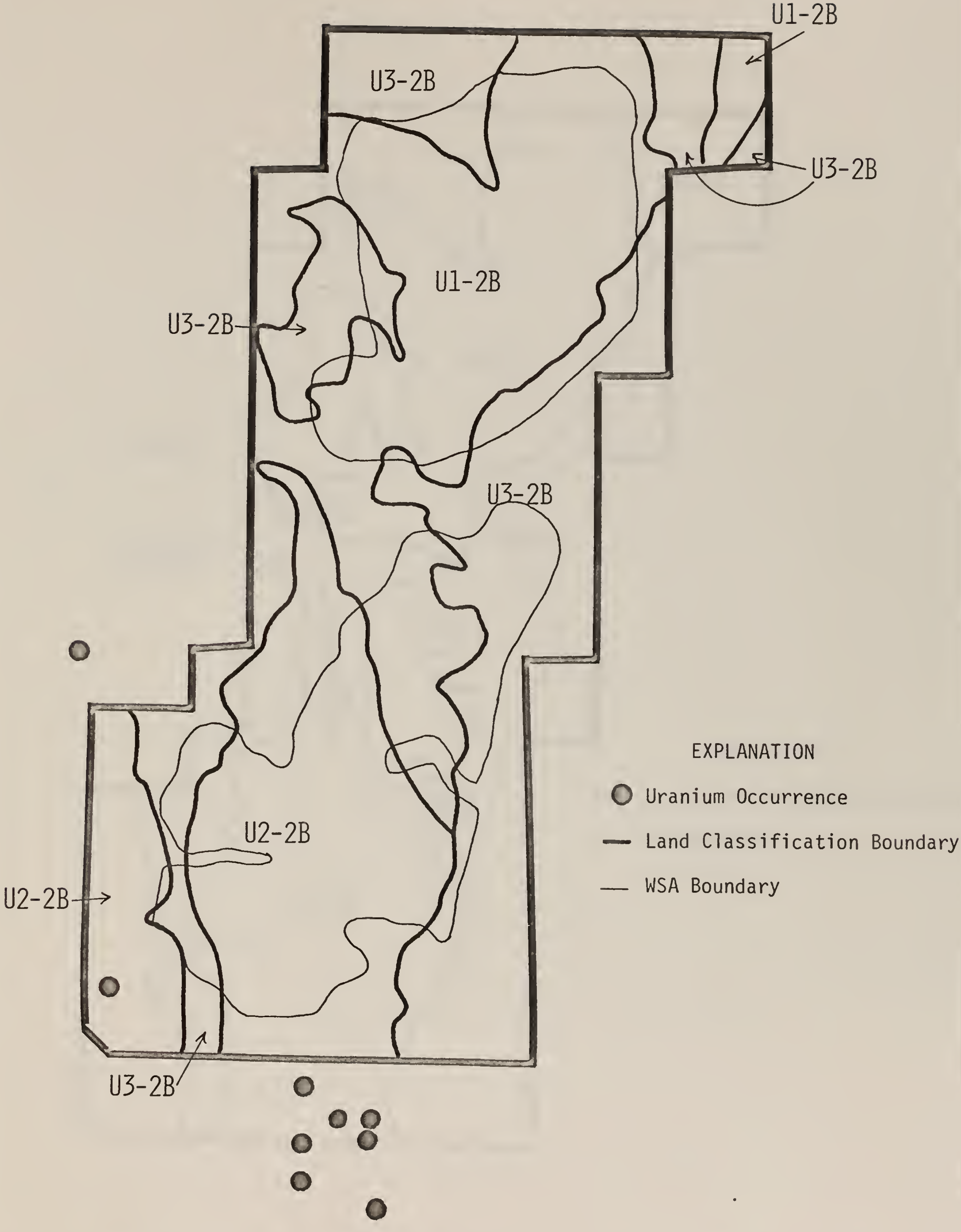


*X denote one or more claims per section


NV-050-0425
NV-050-0435
Oil and Gas Lease Map
1:250,000
X Leased Section
McCULLOUGH RANGE
McCullough Mountain
ELDORADO VALLEY
HIGHLAND RANGE
Hidden Valley
Lucky Dutchman Mine
Radio Facility
Alunite (site)
Bard (site)
Sloan
Erie
Jean
Borax Station
Roach Station
Desert
Water
Ranch
Sheep Mountain
Wallstreet Mine
Desert Queen Well
UNION PACIFIC
R 61 E
R 62 E
R 63 E
T 23 S
T 24 S
T 25 S
T 26 S
T 27 S

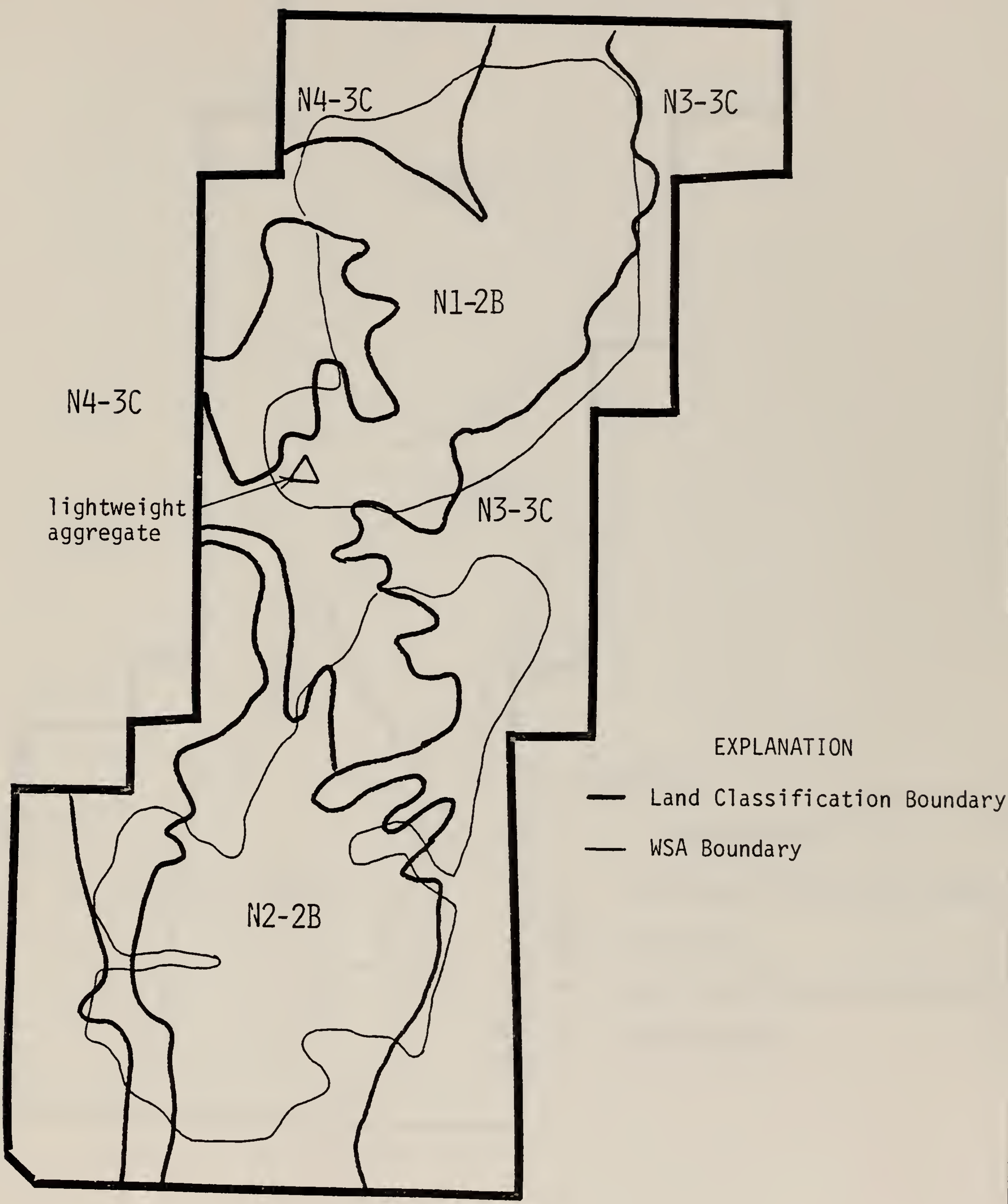


Land Classification - Mineral Occurrence Map/Metallics McCullough Mountains GRA NV-36
Scale 1:250,000



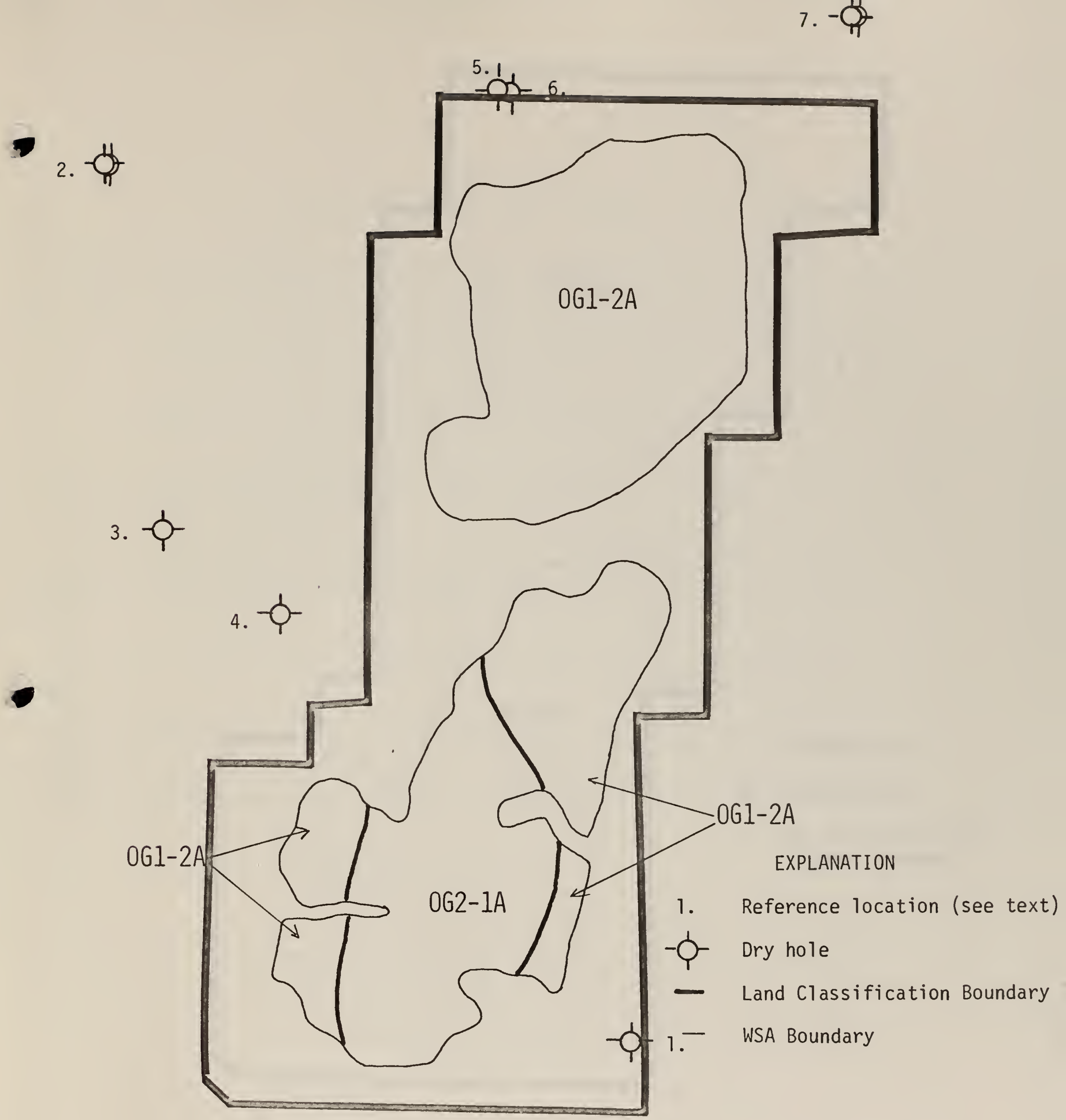
Land Classification - Mineral Occurrence Map/Uranium

McCullough Mountains GRA NV-36
Scale 1:250,000



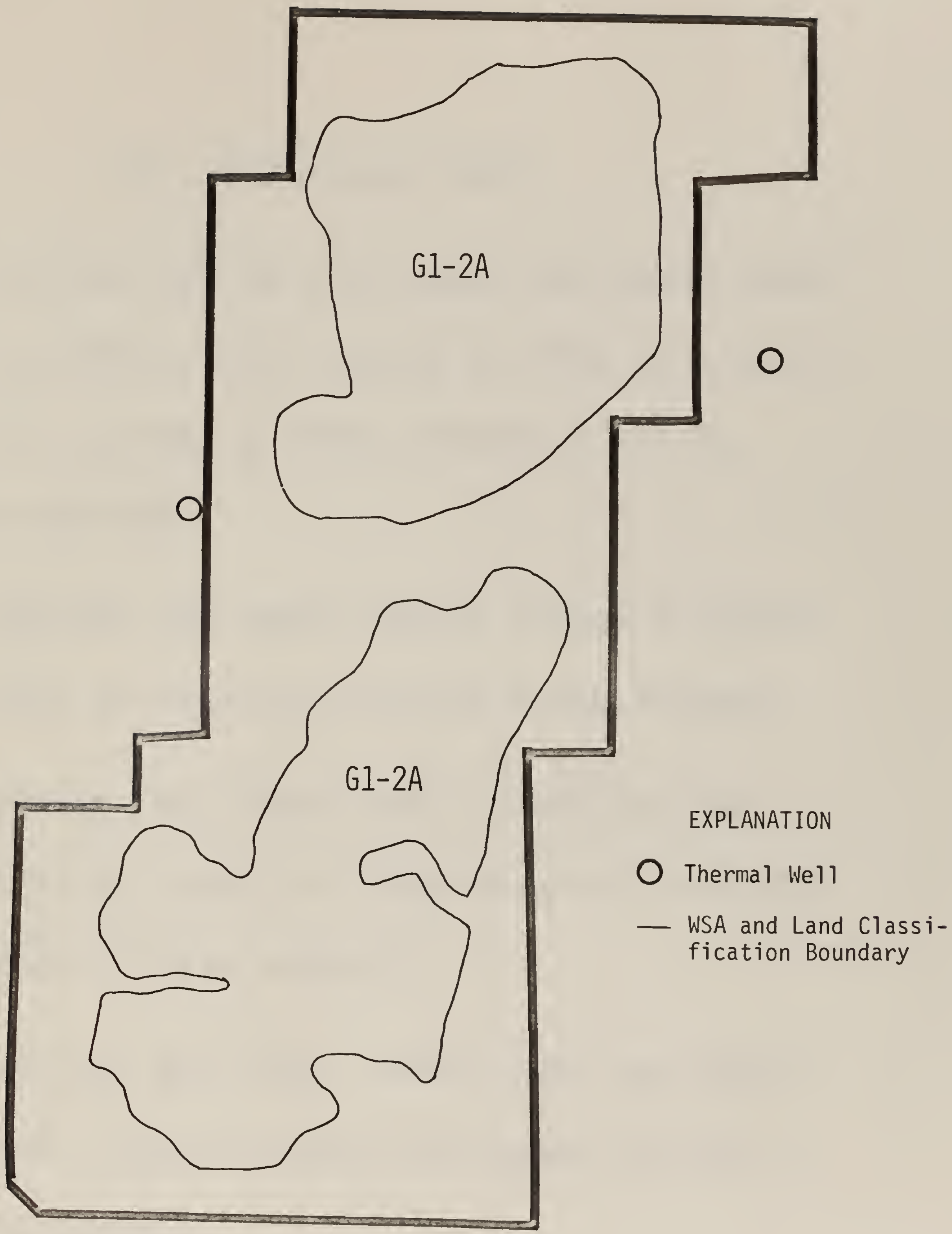
Land Classification - Mineral Occurrence Map/Nonmetallics

McCullough Mountains GRA NV-36
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Oil & Gas

McCullough Mountains GRA NV-36
Scale 1:250,000



Land Classification - Mineral Occurrence Map/Geothermal

McCullough Mountains GRA NV-36
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems: Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Carboniferous Systems: Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [4]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

[1] Holmes, Arthur, 1965, Principles of physical geology: 2d ed., New York, Ronald Press, p. 360-361, for the Pleistocene and Pliocene, and Obradovich, J. D., 1965, Age of marine Pleistocene of California: Am. Assoc. Petroleum Geologists, v. 49, no. 7, p. 1057, for the Pleistocene of southern California.
[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.
[3] Stern, T. W., written commun., 1968, for the Precambrian.
[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

GEOLOGIC NAMES COMMITTEE, 1970